Abstract

γ-TiAl based alloys have attracted considerable research interest in the past few decades and have gained niche high temperature applications in aero-engines and automobiles. As high temperature structural materials, these alloys require stable microstructures. This thesis aims at addressing knowledge gaps in the understanding of microstructural stability in two technologically important γ-TiAl based alloys in different microstructures, viz. fully lamellar (FL) and duplex. Creep and exposure tests were complemented with a variety of microstructural characterization tools (SEM, EBSD, TEM, XRD). Density functional theory based calculations were also performed to further the understanding of stability of phases. In the first part of the thesis, microstructural stability of a FL microstructure was studied under creep and high temperature exposure conditions. An aim of these studies was to probe the effect of stress orientation with respect to lamellar plates on microstructural changes during primary creep. It was observed that retention of excess α_2 resulted in an unstable microstructure and so under stress and temperature, excess α_2 was lost. However, depending on stress orientation, the sequence of precipitates formed was different. In particular, for certain stress orientations, the formation of the non-equilibrium C14 phase was observed. The stress dependence of microstructural evolution was found to be stem from internal stresses due to lattice misfit and elastic moduli mismatch between α_2 and γ. In the second part of this thesis, microstructural stability of a duplex alloy was probed, with an emphasis on understanding mechanisms that lead to tertiary creep. The as-extruded microstructure consisted of bands of equiaxed grains and lamellar grains. During creep, loss of lamellar grains was observed and this was attended by kinking of laths and formation of dynamically recrystallized equiaxed grains. Significant dislocation activity was seen in both lamellar and equiaxed grains at all stages of creep. Initially, dislocation activity leads to strengthening and primary creep behavior, but at later stages, it triggers dynamic recrystallization. Dynamic recrystallization was found to be the rate controlling creep mechanism. Accelerating creep behavior was due to strain localization during the constant load tensile test resulting from microstructural instabilities such as kinking.